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RESEARCH PROJECT COMPLETION REPORT

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## ABSTRACT

The purpose of this study was to estimate the agricultural benefits due to flood protection provided by the proposed Trinity River Project. The area examined was the land located between the 100-year flood plain with the project and without the project. Benefits of the project were defined as reduced flood damages on current land uses and alternatively as increased net returns assuming a shift to a profit maximizing land use with flood protection provided.

Annual flood damages were calculated by applying published seasonal flood damage factors and flood frequency as developed from a producer survey to annual gross returns. Annual net benefits were calculated as net returns with flood protection less net returns without flood protection. The reduction in net returns without flood protection represented annual flood damages with a constant land use assumption. The two estimates of flood protection benefits were developed for evaluation reaches 1 through 6 separately as well as on an aggregate basis.

Total annual net benefits of the Trinity River Project were $676,392.43 assuming current land use and $4,579,688.55 assuming profit maximizing land use after flood protection. These benefits were capitalized to a present value using interest rates of 3¼% and 9%. Under current land use the total benefits were $20,812,074 at 3¼% and $7,515,471 at 9%. Similarily flood protection benefits were $140,913,493 and $50,885,429 respectively assuming the profit maximizing land use. Applying regional income multipliers, the increased annual household income was $2,171,796.66 assuming current land use and $12,163,887.68 assuming all land in the profit maximizing enterprise. The capitalized values of the regional impact were $66,824,513 and $24,131,075 under current land use, and $374,273,469 and $135,154,308 under profit maximizing land use at 3¼% and 9% respectively.

# TABLE OF CONTENTS

# NET BENEFITS TO AGRICULTURE FROM THE TRINITY RIVER PROJECT, TEXAS

## Introduction

The federally approved Trinity River Project, Texas, was authorized by the 89th Congress of the United States in the Rivers and Harbors Act of 1965. The project called for the comprehensive improvement of the Trinity River and was made in accordance with plans formulated by the Galveston and Fort Worth Districts of the U. S. Army Corps of Engineers.

The approved project would develop the river basin's water resources for flood control, water supply, navigation, recreation, fish and wildlife conservation, and related purposes. Future hydroelectric power is a possible benefit that has not been authorized under existing legislation. The initial proposal included a multi-purpose channel extending from Galveston Bay to Fort Worth, a system of locks and dams, four multi-purpose reservoirs, and five local flood protection projects. The original project has been reviewed, updated, and ammended several times since 1962. With dramatic changes in productivity and market value of agricultural products in recent years, there is a need to reconsider the effect of the federally approved Trinity River Project on agricultural productivity in terms of output and economic value.

The importance of agriculture in the Trinity River basin is readily apparent from existing land use. A total area of 17,969 square miles of predominantly agricultural land is drained by the Trinity River. Estimates of land use were made by the Corps of Engineers from 1969-1973 aerial photographs. Their estimates indicated that the 100-year flood plain contained 217,810 acres of forest, 156,513 acres of grasslands, and 67,795 acres of cropland. These estimates excluded land in the Wallisville, Livingston, and Tennessee Colony Lakes. Land use in the Tennessee Colony Lake area alone included 89,323 acres of forest, 80,632 acres of grasslands, and 2,930 acres of cropland (Corps of Engineers, 1975).

The Trinity River basin is currently subject to frequent flooding of high quality agricultural lands. A high flood risk precludes production of high value crops that are most vulnerable to flooding. Consequently, the impact of the Trinity River Project on increasing agricultural productivity is primarily attributable to flood control. The principle flood control features included in the project proposal are the multi-purpose channel and Tennessee Colony Reservoir. Should the highly productive areas of the flood plain become available for production of high value crops through flood control provided by the project it could be expected to have a favorable impact on the economies of the area under consideration.

## Objectives

The overall objective of this study was to estimate the net economic agricultural benefits of the federally approved Trinity River Project by county and in aggregate. The county delineation could not be satisfied due to form in which data were available and was therefore changed to a river evaluation reach basis. Specifically the objectives were as follows:

1. Estimate, by reach and in aggregate, agricultural output attributable to the project.
2. Estimate, by reach and in aggregate, increased net income for agricultural producers attributable to the project.
3. Estimate, by reach and in aggregate, cost of reclamation of

the flood plain that will be required for crop production.

4. Estimate, by reach and in aggregate, reduction in agricultural net income on land inundated by the Tennessee Colony Reservoir.

5. Estimate, by reach and in aggregate, net economic benefits from agriculture attributable to the project.

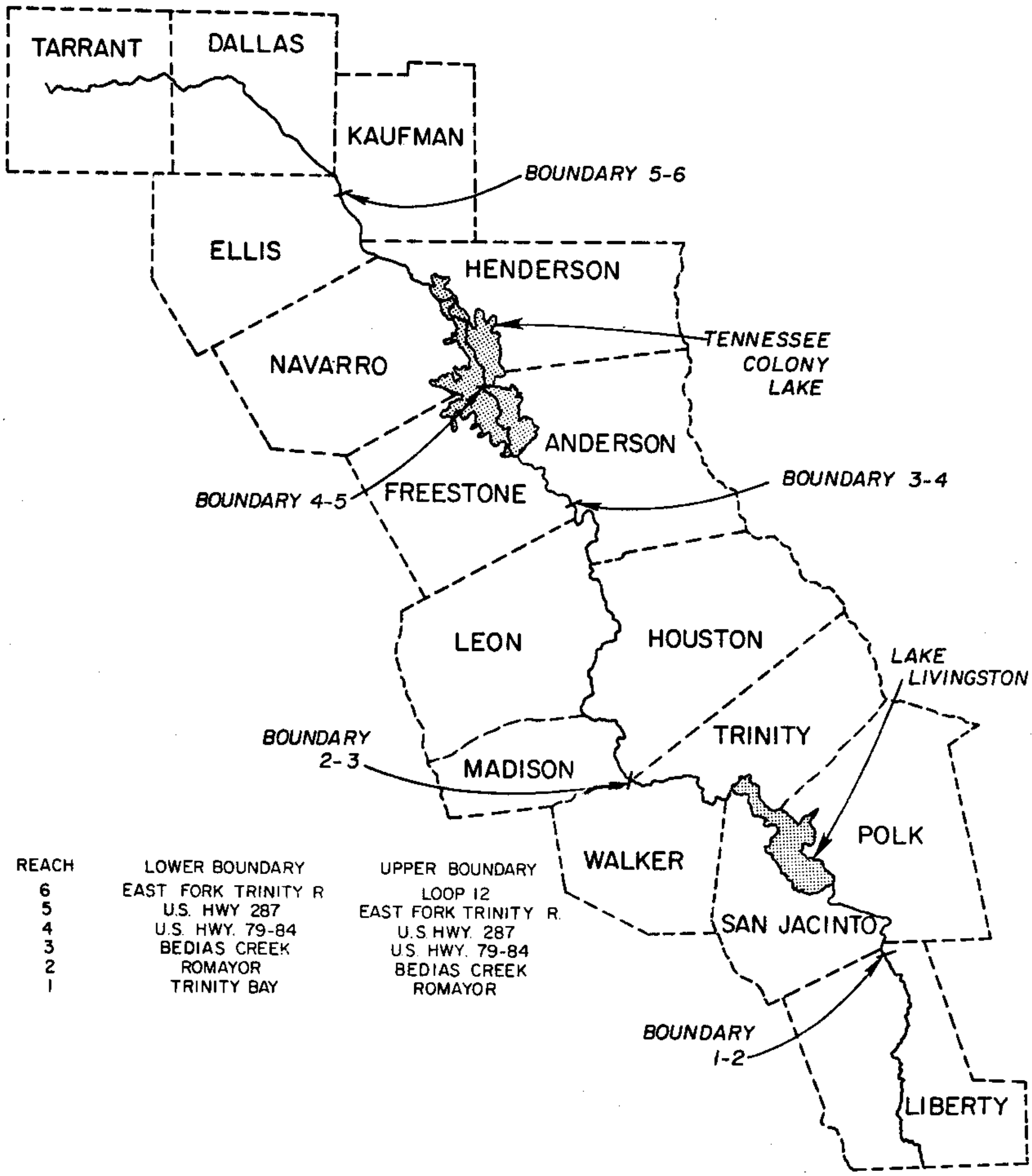
6. Estimate for the region the impact of the project on income and employment.

## Study Area

The study area included the 100-year flood plain of the Trinity River extending from Loop 12 in Dallas southeastward to Trinity Bay. Land inundated by the proposed Tennessee Colony Reservoir was included in the study area. Land inundated by Lake Livingston and proposed reservoirs was excluded from the study area. An additional 3,300 acres of land in the flood plain that would be protected from the 100-year flood with the project in place were excluded due to soils not suitable for crop production.

Since data were not available on a county basis it was necessary to divide the study area into river evaluation reaches. The evaluation reaches used in the study were obtained from data furnished by the Corps of Engineers in 1975. The boundaries for each evaluation reach are given in Table 1 and Figure 1.

Approximately 489,000 acres of land are included in the study area. Existing land use in the 100-year flood plain indicates approximately 44 percent of the flood plain acreage is forest. Thirty percent of the flood plain acreage is grasslands, and 13 percent of the flood plain acreage is cropland. Water surfaces and marshes make up seven percent and the remaining six percent contains man made structures,




| REACH | LOWER BOUNDARY | UPPER BOUNDARY |
|---|---|---|
| 6 | EAST FORK TRINITY R | LOOP 12 |
| 5 | U.S. HWY 287 | EAST FORK TRINITY R. |
| 4 | U.S. HWY. 79-84 | U.S HWY. 287 |
| 3 | BEDIAS CREEK | U.S. HWY. 79-84 |
| 2 | ROMAYOR | BEDIAS CREEK |
| 1 | TRINITY BAY | ROMAYOR |

Figure 1. Study Area

Table 1

Evaluation Reaches and Boundaries for Trinity River Project.

| Reach | Lower Boundary | Upper Boundary |
|---|---|---|
| 1 | Trinity Bay | Romayor |
| 2 | Romayor | Bedias Creek |
| 3 | Bedias Creek | U.S. Hwy. 79-84 |
| 4 | U.S. Hwy. 79-84 | U.S. Hwy. 287 |
| 5 | U.S. Hwy. 287 | East Fork Trinity River |
| 6 | East Fork Trinity River | Loop 12 Dallas |

Source: U.S. Army Corps of Engineers, 1975.

oil and gas fields, and sand and gravel mining (Corps of Engineers, 1975).

Principal agricultural products that are produced in the study area include feed grains, food grains, cotton, and livestock. Major feed grains produced are grain sorghum, corn, oats, and rye. The major food grains are wheat and rice. Cattle production is the primary livestock enterprise and principal agricultural commodity produced in the study area.

## Methodology

To estimate benefits of flood protection from the Trinity River Project it was necessary to establish current land use, reduction in flooding with the project, possible land use changes, and current flooding damages. The basic procedures used to evolve to an estimate of project benefits are presented below.

## Establishing Current Land Use Pattern

Current land use patterns were obtained from the U.S. Army Corps of Engineers, Fort Worth, and the U.S. Department of Agriculture, Soil Conservation Service, Temple. Corps of Engineers personnel used 1969 and 1973 aerial photographs to determine land use within the 100-year flood plain of the Trinity River (U.S. Army Corps of Engineers, 1975). These data were utilized to obtain total acreage within the proposed Tennessee Colony Reservoir and total acreage within the 100-year flood plain of the Trinity River.

Detailed agricultural land use estimates were obtained from unpublished data prepared by the River Basins Staff of the U.S. Department of Agriculture, Soil Conservation Service, Temple. The SCS land use data were collected by field personnel in the study area during 1972. Concurrently, SCS soil scientists assembled soils data for the study area from existing maps. The land use data and soils information were available for the Trinity River flood plain from Loop 12 in Dallas to Trinity Bay excluding the Tennessee Colony, Livingston and Wallisville reservoirs. These data were transferred to U.S. Geological Survey maps for the entire flood plain. Agricultural land use acreage was determined by standard planimeteric techniques. Land not suitable for crop production due to soil conditions was determined by planimetering soils maps.

## Establishing Flood Plain Boundary with Project

The current 100-year flood plain for the Trinity River was obtained from the U.S. Army Corps of Engineers, Fort Worth. Corps of Engineers hydrologists provided maps delineating the existing 100-year flood plain.

This information was transferred to maps containing current land use estimates. The with project 100-year flood plain was obtained from computer data furnished by the Corps of Engineers depicting the proposed maximum water elevations by river mile. These data were plotted on the maps. This gave the 100-year flood plain boundary with and without the Trinity River Project.

For this study the primary focus is the "protected area." The "protected area" refers to land that will not be subjected to flooding by a 100-year frequency or smaller flood after project completion; i.e., land between the existing 100-year flood plain and the proposed maximum water level with project. Acreage within the protected area was used to estimate net agricultural benefits of the Trinity River Project. Land use acreage within the protected area was estimated by standard planimeteric techniques.

## Establishing Agricultural Costs and Returns

Critical to the estimate of benefits of the Trinity River Project is per acre costs and returns to get net returns for each major agricultural enterprise in each evaluation reach. Net returns were calculated from crop and livestock enterprise budgets of the Texas Agricultural Extension Service for production regions which overlap the flood plain of the Trinity River. The production regions were related to an evaluation reach and, hence, appropriate enterprise budgets could be designated for each evalution reach.

Additional crop and livestock enterprise budgets were obtained from the U. S. Department of Agriculture, Soil Conservation Service, Temple to compare yields. The objective was to most accurately approximate the yield occurring from typical management in the area.

Some adjustments were made to yield presented in the Texas Agricultural Extension Service enterprise budgets based on interviews with production-specialists and the SCS yield data. A further enterprise budget modification was in product price. Since agricultural prices vary considerably from year to year a five year average based on reported state prices for the years 1970-1974 were used as unit prices in the enterprise budgets for each evaluation reach (Texas Department of Agriculture, 1975). These figures are shown in Table 2.

Since an average price concept was utilized, it was appropriate that total cost be adjusted to an average of the same time period. This adjustment was made by use of Texas cost of production indexes (Texas Department of Agriculture, 1975). These indexes were utilized in the equations shown below to estimate total costs in the years 1970-1974 with respect to their relationship to 1976 costs. After obtaining an estimate for each of the five years (1970-1974) a simple average was taken to obtain the average total cost.

$$\text{Estimated Costs for year } i = \frac{\text{Index for year } i}{\text{Index 1976}} \text{ X Total Costs 1976}$$

$$i = 1970, \ldots, 1974$$

$$\text{Average Total Cost} = \frac{\text{Sum of Estimated Costs 1970-1974}}{5}$$

The final results of the enterprise budget analysis are shown in Tables 3, 4 and 5. Some evaluation reaches have been combined since they lie within the same crop production region. Gross revenue, total cost and net returns per acre are shown for each crop produced within each evalua-

Table 2

Average Prices Received for Crops and Livestock; 1970-1974.

| Commodity | Unit | Price |
|---|---|---|
| Steers | cwt. | $35.00 |
| Heifers | cwt. | 32.00 |
| Cull cows | cwt. | 24.00 |
| Coastal hay | ton | 33.00 |
| Corn | bu. | 2.00 |
| Cotton lint | lb. | .31 |
| Cotton seed | ton | 74.80 |
| Grain sorghum | cwt. | 3.03 |
| Oats | bu. | 1.00 |
| Peanuts | cwt. | 14.38 |
| Sudan hay | ton | 33.60 |
| Rice | cwt. | 8.42 |
| Soybeans | bu. | 4.27 |
| Wheat | bu. | 2.27 |

Source: Texas Department of Agriculture, 1975.

tion reach.

The livestock budget results are the same across all evaluation reaches since there is not a significant difference in cost or returns identified between any two segments of the flood plain.

Table 3

Per Acre Crop and Pasture Costs and Returns: Evaluation Reach 1

| Crop | Gross Revenue | Total Cost | Net Revenue |
|---|---|---|---|
| | ------------ | dollars | ------------ |
| Rice | 361.56 | 220.30 | 141.26 |
| Soybeans | 106.80 | 83.56 | 23.24 |
| Native pasture | 27.71 | 24.13 | 3.57 |
| Coastal pasture | 55.43 | 63.54 | - 8.11 |
| Brush pasture | 11.08 | 24.13 | -12.05 |

Estimating Flood Damages

For purposes of this study and due to time and financial constraints, only that flood plain area where flooding was eliminated due to the federally approved Trinity River Project was evaluated. It is recognized that the flood plain which would continue to be flooded even with the project in place would be expected to incur reduced losses from flooding. However, this study made no attempt to identify the incidence of reduced depth of flooding or reduced frequency of flooding. Therefore, discussion of methods used apply to the "protected flood plain."

Table 4

Per Acre Crop and Pasture Costs and Returns: Evaluation Reach 2 and 3

| Crop | Gross Revenue | Total Cost | Net Revenue |
|---|---|---|---|
| | -----------------dollars----------------- | | |
| Coastal hay | 273.90 | 221.26 | 52.63 |
| Corn | 130.00 | 76.66 | 53.33 |
| Cotton (seed & lint) | 92.46 | 103.64 | -11.18 |
| Grain Sorghum | 78.78 | 73.33 | 5.44 |
| Oats | 99.40 | 62.20 | 27.19 |
| Peanuts (dryland) | 230.08 | 147.65 | 82.40 |
| Peanuts (irrigated) | 431.40 | 175.89 | 255.51 |
| Rice | 367.70 | 230.22 | 137.56 |
| Soybeans | 106.50 | 67.02 | 39.72 |
| Native pasture | 27.71 | 24.13 | 3.57 |
| Coastal pasture | 55.43 | 63.54 | -8.11 |
| Brush pasture | 11.08 | 24.13 | -12.05 |

Table 5

Per Acre Crop and Pasture Costs and Returns: Evaluation Reach 4, 5, and 6

| Crop | Gross Revenue | Total Cost | Net Revenue |
|---|---|---|---|
| | -----------------dollars----------------- | | |
| Coastal hay | 99.00 | 66.86 | 32.14 |
| Corn | 90.00 | 62.22 | 27.78 |
| Cotton (lint & seed) | 110.95 | 113.26 | -2.31 |
| Grain sorghum | 106.50 | 67.85 | 38.20 |
| Oats (grain & grazing) | 89.50 | 58.44 | 31.06 |
| Sudan hay | 117.60 | 90.95 | 26.65 |
| Wheat (grain & grazing) | 106.25 | 55.91 | 50.34 |
| Native pasture | 27.71 | 24.31 | 3.57 |
| Coastal pasture | 55.43 | 63.54 | - 8.11 |
| Brush pasture | 11.08 | 25.13 | -12.05 |

## Establishing Flooding Incidence in Protected Area

For that part of the flood plain that will no longer flood with a 100-year storm after the Trinity River Project is in place (protected area), current flood conditions (without project) were established by evaluation reach through a farmer enumeration. A questionnaire was developed to ascertain frequency of flooding in the "protected area" and depth by storm size. This provided the basic data required for estimating average annual flood damages.

A total of 32 farmers were interviewed and each one operated a farm in the Trinity River flood plain. Through the survey of producers, opinions of the Trinity River Project and possible land use shifts with the project were obtained.

## Flooding Damages

Flooding damages per acre were estimated for each land use by evaluation reach. Crop damage factors by crop, month and depth of inundation were applied (U. S. Department of Agriculture, 1959). Damage factors indicate expected reduction in gross revenue by crop and date. These factors take into consideration any reduced harvesting costs, land reclamation, etc.

Probability of a flood within three periods of the year (March through June, July through October and November through February) were provided by Mr. James Cunningham of the Corps of Engineers (1975). The monthly crop damage factors by crop and depth of inundation were averaged for each of the three periods above to obtain a seasonal crop damage factor. These seasonal crop damage factors were then adjusted by probability of a flood occurring within each of the seasons. This gives a weighted seasonal crop damage factor, necessary for estimating average annual flood damages.

In notation form, the calculations above are given as:

$$SCDF_{ijk} = (\sum_{m=1}^{4} CDF_{ijm}) \div 4 \qquad (1)$$

where

$SCDF_{ijk}$ = seasonal crop damage factor for depth increment i, crop j and season k

$CDF_{ijm}$ = crop damage factor for depth increment i, crop j and four month period m

m = month designation with four months in each season k. Specific seasons were defined as March through June, July through October and November through February.

$$WSCDF_{ijkn} = SCDF_{ijk} \cdot PF_{kn} \qquad (2)$$

where

$WSDF_{ijkn}$ = weighted seasonal crop damage factor for depth increment i, crop j, season k and evaluation reach n

$PF_{kn}$ = probability of a flood occurring in season k and evaluation reach n.

Damages due to flooding were estimated by applying the seasonal weighted crop damage factors. Expected flood damages for a particular flood size in the year it occurs, where date of occurrence is unknown, are calculated as:

$$DAM_{ijn} = \sum_{k=1}^{3} (GR_{jn} \cdot WSCDF_{ijkn}) \qquad (3)$$

where

$DAM_{ijn}$ = expected flood damages from a flood size associated with inundation depth increment i, crop j and evaluation reach n

$GR_{jn}$ = gross revenue from crop j in evaluation reach n in the absence of flooding.

To express this value in terms of average annual flood damages attributable to this flood size, the damages must be adjusted by frequency of the flood size. For example, if the flood occurs every five years, then $DAM_{ijn}$ would be multiplied by .20 to get expected flooding damages for flood size i in any given year; i.e., the flood has only a probability of 20 percent of occurring in any given year.

To estimate average annual flood damages, the flood damage value as calculated above for each flood size were aggregated according to the probability of occurrence. The calculation for average annual flood damages is as follows:

$$AFD_{jn} = \sum_{i=1}^{3} (DAM_{ijn} \cdot AP_i)$$

where

$AFD_{jn}$ = average annual flood damages to crop j in evaluation reach n

$AP_i$ = probability of flood size i where i is divided into three increments (0-1 foot, 1-3 feet, and over 3 feet).

Estimating Project Benefits

Benefits of the federally approved Trinity River Project were estimated with two basic assumptions which provides an upper and lower bound or expected range in project benefits to agriculture. Initially, benefits were estimated assuming no change in land use (reduced damages due to reduced flooding) which provides the lower bound. Alternatively benefits were estimated assuming an adjustment after project completion to the profit maximizing land use. Project related costs were not considered. For the Tennessee Colony Reservoir, the loss in expected net revenue on acres inundated was included as a cost or negative benefit.

Reduced Flooding

Using the 1973 land use pattern in the flood plain, the average annual flood damages in the protected area were estimated by applying the previously discussed damage values. The average annual flood damages per acre for each crop were subtracted from net returns indicated by the enterprise budgets to estimate an adjusted net return figure. Adjusted net returns correspond to the expected net returns with flood damages (without project). With current land use, the per acre benefits of flood control were calculated as enterprise budget net returns less adjusted net returns. The net benefits are therefore equal to the flood damages since these flooding damages would be eliminated with the project.

Per acre benefits per crop were multiplied by the number of acres in each crop for each evaluation reach. The sum of crop benefits in each reach is estimated total benefits to the specific evaluation reach. The total benefits for each evaluation reach were aggregated to obtain the total project benefits to agriculture. This represents a lower bound on project benefits since land use adjustments were not considered.

## Alternative Land Use

An upper limit of project benefits was estimated by assuming all land in the protected area would shift to the profit maximizing agricultural use after project completion. The profit maximizing use was assumed as the agricultural enterprise with the highest enterprise budget net returns. The benefits accruing to this land use from flood protection were calculated as enterprise budget net returns from profit maximizing enterprise less reclamation costs less adjusted net returns of the current land use.

Reclamation costs represent the cost of changing pasture and wooded pasture to cropland. No cost was assumed to change land use on existing cropland. Estimates of reclamation costs were obtained from area U. S. Department of Agriculture Soil Conservation Service offices. An average of $50 per acre total cost was adopted for changing pasture to cropland. A total conversion cost of $150 per acre was used for changing from wooded pasture to cropland. To express these conversion costs on an annual basis, the total costs were amortized over 10 years at nine percent interest. Thus the annual per acre cost for a change to cropland from pasture was $7.79, and $23.37 from wooded pasture.

The net benefits from profit maximizing land use is an overestimate of project benefit since there currently exist opportunities for producers to shift land use in the flood plain and consequently increase net revenue. Nonetheless, the procedures followed herein provide an upper and lower boundary or range in total agricultural benefits attributable to the Trinity River Project.

Regional Impact

The total regional benefits from flood control were calculated by multiplying the total agricultural net benefits under current land use and profit maximizing land use by regional income multipliers developed in 1967 (Stern, 1972: Mullendore, Ekholm, Hayashi, 1972). Income multipliers indicate the degree of economic activity generated throughout a region from a change in the output within a specific sector of the economy.

The procedure for calculating income multipliers is as follows (Lippke, 1971):

$$M(I)_j = \sum_{i=1}^{m} (a_{hi} \cdot A_{ij})/a_{hj}$$

where

$M(I)_j$ = Type I income multiplier for sector j

$a_{hi}$ = household technical coefficient for sector i

$a_{hj}$ = household technical coefficient for sector j

$A_{ij}$ = estimate of both the direct and indirect effects on sector i of an increase in final demand for sector j.

Capitalization of Benefits

The present values of the annual net benefits and the annual regional impact were computed to estimate the total impact of reduced flooding over time. This was done by applying the capitalization equation for an infinite time period as follows (Hopkin, Barry and Baker, 1973):

$$Vo = \frac{A}{i}$$

where

Vo = the present value of the series of returns

A = the constant annual returns

i = the discount rate.

## Results

The benefits described in this study apply only to the land in the protected area. This protected area is the land lying between the 100-year flood plain with and without the Trinity River Project. As explained in the methodology section, flood protection benefits were calculated assuming current land use and as increased net returns assuming a shift of land into the profit maximizing agricultural enterprise. The total increase in agricultural output was also calculated assuming both current land use and profit maximizing land use.

## Returns and Damages Per Acre

The net returns per acre as calculated via the enterprise budgets, average annual flood damages per acre, and total acres of each crop by evaluation reach are presented in Table 6. Eleven crops were evident throughout the Trinity River floodplain. In most evaluation reaches, however, only a few of the crops were produced.

Table 6 shows that cotton and wooded pasture had negative per acre net returns. For these crops and for crops where average annual flood damages exceed enterprise budget net returns, adjusted net returns per acre were negative. For example, for cotton in reach 2, adjusted net returns per acre were calculated as negative $11.18 less average annual flood damages of $33.08 which resulted in expected net returns per acre of negative $44.26. One measure of project net benefits per acre would be the average annual flood damages.

Examination of Table 6 also shows that the majority of the land was in pasture or wooded pasture. From personal interviews with producers along the flood plain, it was determined that in many instances this use was directly attributable to flooding. Due to the frequency of floods, much land which was previously in crop production had since been converted to grazing since grazing use is much less vulnerable to flooding.

## Profit Maximizing Land Use

Table 7 shows the profit maximizing agricultural land use for each reach with flood protection, and the number of acres which were assumed to change to this land use. All land within the protected area was assumed to change to the profit maximizing use. These profit maximizing land uses were

Table 6

Annual Net Returns per Acre[a], Average Annual Flood Damages per Acre, and Total Acreage for Crops in Protected Area[b], Between 100 year Flood plain Boundaries (with project and without project), Trinity River.

| Land Use | Reach 1 | | | Reach 2 | | | Reach 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Net Returns | Avg. Annual Flood Damages | Total Acres | Annual Net Returns | Avg. Annual Flood Damages | Total Acres | Annual Net Returns | Avg. Annual Flood Damages | Total Acres |
| | --------per acre-------- | | | --------per acre-------- | | | --------per acre -------- | | |
| Annual Hay (Sudan) | | | | | | | 26.65 | 19.20 | 20 |
| Corn | | | | | | | 53.33 | 16.95 | 540 |
| Cotton | | | | -11.18 | 33.08 | 34 | -11.18 | 12.52 | 7329 |
| Grain Sorghum | | | | | | | 5.44 | 17.96 | 4337 |
| Hay (Coastal Bermuda) | | | | 52.63 | 60.19 | 62 | 52.63 | 22.59 | 845 |
| Oats | | | | | | | 37.19 | 8.37 | 140 |
| Pasture | 3.58 | 3.53 | 470 | 3.58 | 3.75 | 4999 | 3.58 | 1.40 | 33,306 |
| Rice | 141.26 | 278.40 | 1521 | | | | | | |
| Soybeans | | | | | | | 39.72 | 14.46 | 213 |
| Wheat | | | | | | | 50.34 | 11.84 | 472 |
| Wooded Pasture | | | | -.99 | 1.50 | 2989 | -.99 | .56 | 10,480 |

[a]1970-1974 average

[b]Source: Soil Conservation Service 1972

Table 6 (Continued)

| Land Use | Reach 4 | | | Reach 5 | | | Reach 6 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Annual Net Returns | Avg. Annual Flood Damages | Total Acres | Annual Net Returns | Avg. Annual Flood Damages | Total Acres | Annual Net Returns | Avg. Annual Flood Damages | Total Acres |
| | --------per acre-------- | | | --------per acre-------- | | | --------per acre-------- | | |
| Annual Hay (Sudan) | | | | 26.65 | 9.43 | 84 | | | |
| Corn | | | | | | | | | |
| Cotton | | | | | | | -2.31 | 31.71 | 12 |
| Grain Sorghum | 38.20 | 17.76 | 45 | 38.20 | 12.45 | 124 | 38.20 | 18.65 | 519 |
| Hay (Coastal Bermuda) | | | | 32.14 | 11.73 | 79 | 32.14 | 17.09 | 36 |
| Oats | | | | | | | | | |
| Pasture | 3.58 | 2.80 | 5374 | 3.58 | 1.95 | 2667 | 3.58 | 2.94 | 353 |
| Rice | | | | | | | | | |
| Soybeans | | | | | | | | | |
| Wheat | 50.34 | 24.85 | 5 | 50.34 | 16.45 | 107 | 50.34 | 26.74 | 182 |
| Wooded Pasture | -.99 | 1.12 | 570 | -.99 | .79 | 3130 | -.99 | 1.18 | 112 |

rice in Reaches 1 and 2, corn in Reach 3, and wheat in Reaches 4, 5 and 6. Table 8 shows the per acre net returns for the profit maximizing crops adjusted for reclamation or conversion costs.

These assumptions are limited to a great extent in that some land may not be suitable for crop production. For example, to produce rice requires land with less than a one percent slope (Grant, 1975). From examination of soil maps, it was determined that approximately 3,300 acres are unsuitable for crop production due to soil conditions. In lieu of these limitations, these figures may still serve as an upper bound on the amount of land available for the profit maximizing use.

Table 7

Total Acreage of Land Between 100-Year Flood Plain Boundaries (with project and without project) Assumed Placed in Most Profitable Alternative Enterprise, Trinity River.

| Evaluation Reach | Most Profitable Alternative Enterprise | Total Acres Placed in Most Profitable Enterprise |
|---|---|---|
| Reach 1 | Rice | 1,991 |
| Reach 2 | Rice | 8,084 |
| Reach 3 | Corn | 57,682 |
| Reach 4 | Wheat | 5,994 |
| Reach 5 | Wheat | 6,191 |
| Reach 6 | Wheat | 1,214 |

## Agricultural Output

A major effect of flood control from the Trinity River Project would be increased agricultural output due to a reduction in flood damages to

Table 8

Net Returns, Cost of Conversion and Adjusted Net Returns per Acre for most profitable alternative enterprises, by Reach, Trinity River.

| Evaluation Reach | Most Profitable Alternative Enterprise | Net Returns Per Acre | Per Acre Cost of Conversion from Pasture to Cropland[a] | Per Acre Cost of Conversion from Wooded Pasture to Cropland[b] | Adjusted Net Returns per Acre For Former Pasture | Adjusted Net Returns per Acre For Former Wooded Pasture |
|---|---|---|---|---|---|---|
| | | - - - - - - | - - - - - - | - - Dollars - - | - - - - - - | - - - - - - |
| Reach 1 | Rice | $141.26 | $7.79 | $23.37 | $133.47 | $117.89 |
| Reach 2 | Rice | 137.56 | 7.79 | 23.37 | 129.77 | 114.19 |
| Reach 3 | Corn | 53.33 | 7.79 | 23.37 | 45.54 | 29.96 |
| Reach 4 | Wheat | 50.34 | 7.79 | 23.37 | 42.55 | 26.97 |
| Reach 5 | Wheat | 50.34 | 7.79 | 23.37 | 42.55 | 26.97 |
| Reach 6 | Wheat | 50.34 | 7.79 | 23.37 | 42.55 | 26.97 |

[a]$50 total cost amortized over 10 years at 9%.

[b]$150 total cost amortized over 10 years at 9%.

crop and grazing land. The total agricultural output with and without the project under current land use as well as total agricultural output with land in the profit maximizing use with the project was estimated. These estimates of agricultural output apply only to the protected area.

Current Land Use

Table 9 shows the total output with current land use for each evaluation reach. Total output with the project is the expected output as given by the Texas Agricultural Extension Service budgets. Total output without the project accounts for flood damages to the enterprise budget production figure. Increased output with flood control is the difference between total output with and without the project.

The effects of flood control vary among evaluation reaches and among the different crops within a reach. For example, with flood control, cotton output in Reach 2 is expected to increase 55 percent while in Reach 3 it is shown to increase only 16 percent. The amount of increase in cotton in Reach 3 can be compared to the expected increase in grain sorghum output in the same reach which is about 30 percent.

Total agricultural output throughout the protected area of the Trinity River with and without the project is shown in Table 10 and is simply an aggregation of each reach output. The expected increase in production is 10.3 percent for annual hay, 15 percent for corn, 16 percent for cotton, 28 percent for grain sorghum and 10.3 percent for hay. Similarly, the expected increased production is 9.4 percent for oats, 7 percent for pasture, 335 percent for rice, 16 percent for soybeans, 18 percent for wheat and 7.7 percent for wooded pasture. Excluding the large predicted

Table 9

Total Annual Agricultural Output by Reach, with and without Project, and Change in Output Associated with Flood Control Given Land stays in Current Use after Flood Control is Established, Trinity River.

| Land Use | Units | Reach 1 | | | Reach 2 | | | Reach 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Yield With Project (Current Land Use) | Total Yield without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Current Land Use) | Total Yield without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Current) Land Use) | Total Yield without Project (Current Land Use) | Change in Yield With Flood Control |
| Annual Hay (Sudan) | Ton | | | | | | | 70 | 60 | 10 |
| Corn | Bu. | | | | | | | 35,100 | 30,550 | 4,550 |
| Cotton | Lbs. | | | | 8,500 | 5,500 | 3,000 | 1,832,250 | 1,584,250 | 248,000 |
| Grain Sorghum | Cwt. | | | | | | | 112,762 | 87,055 | 25,707 |
| Hay (Coastal Bermuda) | Ton | | | | 515 | 402 | 113 | 7,014 | 6,433 | 581 |
| Oats | Bu. | | | | | | | 5,600 | 5,120 | 480 |
| Pasture | A.U. | 94 | 82 | 12 | 1,000 | 865 | 135 | 6,661 | 6,325 | 336 |
| Rice | Cwt. | 65,312 | 15,029 | 50,283 | | | | | | |
| Soybeans | Bu. | | | | | | | 5,325 | 4,600 | 725 |
| Wheat | Bu. | | | | | | | 11,800 | 10,485 | 1,315 |
| Wooded Pasture | A.U. | | | | 299 | 258 | 41 | 1,048 | 995 | 53 |

Table 9 (Continued)

| Land Use | Units | Reach 4 | | | Reach 5 | | | Reach 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Yield With Project (Current Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Current Land Use) | Total Yield without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Current Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control |
| Annual Hay (Sudan) | Ton | | | | 294 | 270 | 24 | | | |
| Corn | Bu. | | | | | | | | | |
| Cotton | Lbs. | | | | | | | 3,600 | 2,571 | 1,029 |
| Grain Sorghum | Cwt. | 1,575 | 1,330 | 245 | 4,340 | 3,830 | 510 | 18,165 | 14,980 | 3,185 |
| Hay (Coastal Bermuda) | Ton | | | | 237 | 210 | 27 | 108 | 90 | 18 |
| Oats | Bu. | | | | | | | | | |
| Pasture | A.U. | 1,075 | 966 | 109 | 533 | 496 | 37 | 71 | 63 | 8 |
| Rice | Cwt. | | | | | | | | | |
| Soybeans | Bu. | | | | | | | | | |
| Wheat | Bu. | 125 | 100 | 25 | 2,675 | 2,250 | 425 | 4,550 | 3,400 | 1,150 |
| Wooded Pasture | A.U. | 57 | 51 | 6 | 313 | 291 | 22 | 11 | 10 | 1 |

Table 10

Total Annual Agricultural Output for Reaches 1-6, with and without Project, and Change in Output Associated with Flood Control Given Land Stays in Current Use after Flood Control is Established, Trinity River.

| Land Use | Unit | Total Yield With Project (Current Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control |
|---|---|---|---|---|
| Annual Hay (Sudan) | ton | 364 | 330 | 34 |
| Corn | bu. | 35,100 | 30,550 | 4,550 |
| Cotton | lbs. | 1,844,350 | 1,592,321 | 252,029 |
| Grain Sorghum | cwt. | 136,842 | 107,195 | 29,647 |
| Hay (Coastal Bermuda) | ton | 7,874 | 7,135 | 739 |
| Oats | bu. | 5,600 | 5,120 | 480 |
| Pasture | A.U. | 9,434 | 8,797 | 637 |
| Rice | cwt. | 65,312 | 15,029 | 50,283 |
| Soybeans | bu. | 5,325 | 4,600 | 725 |
| Wheat | bu. | 19,150 | 16,235 | 2,915 |
| Wooded Pasture | A.U. | 1,728 | 1,605 | 123 |

increase in output of rice, these figures indicate that increased flood control could result in an average of 10 to 15 percent greater output for all agricultural production.

## Profit Maximizing Land Use

To establish an upper bound of expected project benefits, it was assumed that with flood protection provided by the Trinity River Project, all land in the protected area would switch to the profit maximizing agricultural use. For this reason all output from current land use except the profit maximizing enterprise was displaced in the switch of land use. The effects of the change in land use for each evaluation reach are presented in Table 11. In Reach 1, where pasture and rice are currently produced, it was assumed that all pasture land would switch to rice production. This resulted in a 100 percent loss of current pasture production, but an increase of 469 percent in expected rice production.

In Reach 2, rice was determined to be the profit maximizing land use. Although there is no current rice production, for this scenario it was assumed that all land would switch to rice production. In Reach 3 all land was changed to corn production, while in Reaches 4, 5 and 6 wheat production displaced all current land use.

The total aggregate agricultural output for Reaches 1 through 6, with profit maximizing land use is shown in Table 12. Current production of all crops, other than those determined to have the highest per acre net returns, decline to zero. Corn production was estimated to increase by approximately 12,173 percent from 30,550 bushels to 3,718,780 bushels. A 2,779 percent increase in total rice output was projected, from 15,029 cwt.

Table 11

Total Annual Agricultural Output by Reach, with and without Project, and Change in Output Associated with Flood Control Given Land Shifts to the Most Profitable Alternative Enterprise after Flood Control is Established, Trinity River.

| Land Use | Units | Reach 1 | | | Reach 2 | | | Reach 3 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control |
| Annual Hay (Sudan) | Ton | | | | | | | 0 | 60 | -60 |
| Corn | Bu. | | | | | | | 3,749,330 | 30,550 | 3,718,780 |
| Cotton | Lbs. | | | | 0 | 5,500 | -5,500 | 0 | 1,584,250 | -1,584,250 |
| Grain Sorghum | Cwt. | | | | | | | 0 | 87,055 | -87,055 |
| Hay (Coastal Bermuda) | Ton | | | | 0 | 402 | -402 | 0 | 6,433 | -6,433 |
| Oats | Bu. | | | | | | | 0 | 5,120 | -5,120 |
| Pasture | A.U. | 0 | 82 | -82 | 0 | 865 | -865 | 0 | 6,325 | -6,325 |
| Rice | Cwt. | 85,494 | 15,029 | 70,465 | 347,127 | 0 | 347,127 | | | |
| Soybeans | Bu. | | | | | | | 0 | 4,600 | -4,600 |
| Wheat | Bu. | | | | | | | 0 | 10,485 | -10,485 |
| Wooded Pasture | A.U. | | | | 0 | 258 | -258 | 0 | 995 | -995 |

Table 11 (Continued)

| Land Use | Units | Reach 4 | | | Reach 5 | | | Reach 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control | Total Yield With Project (Most Profitable Land Use) | Total Yield Without Project (Current Land Use) | Change in Yield With Flood Control |
| Annual Hay (Sudan) | Ton | | | | 0 | 270 | -270 | | | |
| Corn | Bu. | | | | | | | | | |
| Cotton | Lbs. | | | | | | | 0 | 2,571 | -2,571 |
| Grain Sorghum | Cwt. | 0 | 1,330 | -1,330 | 0 | 3,830 | -3,830 | 0 | 14,980 | -14,980 |
| Hay (Coastal Bermuda) | Ton | | | | 0 | 210 | -210 | 0 | 90 | -90 |
| Oats | Bu. | | | | | | | | | |
| Pasture | A.U. | 0 | 966 | -966 | 0 | 496 | -496 | 0 | 63 | -63 |
| Rice | Cwt. | | | | | | | | | |
| Soybeans | Bu. | | | | | | | | | |
| Wheat | Bu. | 149,850 | 100 | 149,750 | 154,775 | 2,250 | 152,525 | 30,350 | 3,400 | 26,950 |
| Wooded Pasture | A.U. | 0 | 51 | -51 | 0 | 291 | -291 | 0 | 10 | -10 |

Table 12

Total Annual Agricultural Output for Reaches 1-6, with and without Project, and Change in Output Associated with Flood Control Given Land Shifts to the Most Profitable Alternative Enterprise after Flood Control is Established, Trinity River.

| Land Use | Unit | Total Yield With Project (Most profitable Land Use) | Total Yield Without Project (Current land use) | Change in Yield with Flood Control |
|---|---|---|---|---|
| Annual Hay (Sudan) | ton | 0 | 330 | -330 |
| Corn | bu. | 3,749,330 | 30,550 | 3,718,780 |
| Cotton | lbs. | 0 | 1,592,321 | -1,592,321 |
| Grain Sorghum | cwt. | 0 | 107,195 | -107,195 |
| Hay (Coastal Bermuda) | ton | 0 | 7,135 | -7,135 |
| Oats | bu. | 0 | 5,120 | -5,120 |
| Pasture | A.U. | 0 | 8,797 | -8,797 |
| Rice | cwt. | 432,621 | 15,029 | 417,592 |
| Soybeans | bu. | 0 | 4,600 | -4,600 |
| Wheat | bu. | 334,975 | 16,235 | 318,740 |
| Wooded Pasture | A.U. | 0 | 1,605 | 1,605 |

to 417,592 cwt. Wheat production was estimated to rise by approximately 1,963 percent from 16,235 bushels to 318,740 bushels. This is an overestimate for the profit maximizing land uses since (1) all land is not suitable for crop production, and (2) institutional and historical land use patterns would not be expected to radically change.

Flood Control Benefits

The total increases in annual net returns with flood protection from the Trinity River Project assuming current land use and profit maximizing land use are presented in Table 13. The estimates assuming current land use provide a lower bound of the net benefits since this presumes no change in land use. The net benefits attributed to the project were calculated by subtracting net returns without the project from net returns with the project, both assuming current land use; i.e., no change in land use.

Annual net benefits with all land in the profit maximizing enterprise after project installation is equal to total net returns with the project with profit maximizing land use less total net returns without the project under current land use. These estimates provide an upper limit or bound of net benefits. The upper limit is considered to be an overestimate since there are currently opportunities to switch to a more profitable land use, even without flood protection, which are often disregarded and the unlikely complete shifts in land use even with the project for the reasons previously discussed.

Due to the degree of flood damages and the high degree of land use with low net returns such as pasture and wooded pasture, total current annual net returns in Reaches 1, 2 and 3 were estimated as negative

Table 13

Annual Net Returns with and without Project Based on Current and Most Profitable Land Use, Cost of Land Lost to Tennessee Colony Reservoir, and Net Benefits by Reach and Total Area, Trinity River.[a]

| Evaluation Reach | Annual Net Returns with Project, Current Land Use (1) | Annual Net Returns with Project All Land in Most Profitable Enterprise (2) | Annual Net Returns without Project, Current Land Use (3) | Annual Net Benefits from Project Current Land Use (Col. 1-Col. 3) | Annual Net Benefits from Project All Land in Most Profitable Enterprise (Col. 2-Col.3) |
|---|---|---|---|---|---|
| | ---dollars--- | | | | |
| Reach 1 | 216,539.06 | 277,587.36 | -208,566.44 | 425,105.50 | 486,153,80 |
| Reach 2 | 17,820.25 | 1,003,239.90 | - 10,266.00 | 28,086.25 | 1,013,505.90 |
| Reach 3 | 161,746.33 | 2,571,809.72 | - 98,868.28 | 260,614.61 | 2,670,678.00 |
| Reach 4 | 20,645.32 | 246,553.60 | 4,036.27 | 16,609.05 | 242,517.33 |
| Reach 5 | 21,350.00 | 217,730.91 | 8,653.91 | 12,696.09 | 209,077.00 |
| Reach 6 | 31,269.86 | 55,745.45 | 14,558.09 | 16,711.77 | 41,187.36 |
| TOTAL | 469,370.82 | 4,372,666.94 | -290,452.45 | 759,823.27 | 4,663,119.39 |
| Less Annual Net Revenue Lost due to Inundation of Tennessee Colony Reservoir | | | 83,430.84 | | |
| Adjusted Annual Net Benefits | | | | 676,392.43 | 4,579,688.55 |

[a]Net returns are based on cost of production and product prices averaged over the 1970-74 period.

values. When these values were subtracted from the total net returns with flood protection, reasonably attractive annual net benefits were indicated. This was also the case for the aggregate net benefits for Reaches 1 through 6.

Assuming current land use, the largest annual net benefits were estimated to accrue to Reach 1 with $425,105.50 and Reach 3 with $260,614.61. The aggregate annual net benefits of the project were estimated at $759,823.27.

Assuming all land in the profit maximizing enterprise with the project, the largest annual net benefits were estimated for Reach 2 with $1,013,505.90 and Reach 3 with $2,670,678. Aggregate annual net benefits for Reaches 1 through 6 were estimated at $4,663,119.39.

To estimate adjusted annual aggregate net benefits, the annual net revenue from land to be inundated by the Tennessee Colony Reservoir was subtracted from annual aggregate net benefits. This annual loss of $83,430.84 should be subtracted from the benefits in Reaches 4 and 5, but due to the unavailability of the amount of land lost in each reach, disaggregation was not included in this report. The majority of the acreage to be inundated is currently forest or grazing land which yield from essentially zero to negative net returns. Only 1.7 percent of Tennessee Colony Reservoir acres, 2,930, is cropland and these acres are all that show a positive net revenue based on the input and product prices used in this study.

The adjusted annual aggregate net benefits of the Trinity River Project were estimated as $676,392.43 assuming current land use and $4,579,688.55 assuming profit maximizing land use.

The annual net benefits were converted to a present value to show the total expected benefits from the project over time. These values were computed using two interest rates, 3¼% which is the investment cost utilized by the Corps of Engineers in their Trinity River studies, and 9% which should provide a reliable estimate of current cost of capital. The capitalized net benefits for each evaluation reach as well as the total net benefits are presented in Table 14. Assuming current land use, the capitalized net benefits were $20,812,074 at 3¼% and $7,515,471 at 9%. With the assumption of all land being placed in the profit maximizing enterprise, net benefits were $140,913,493 at 3¼% and $50,885,429 at 9%.

Regional Impact

The regional impact of the annual net benefits of the Trinity River Project was determined by applying income multipliers for each agricultural sector to the increased net returns from each agricultural enterprise. The regional impact for each evaluation reach as well as the total regional impact are presented in Table 15. These figures represent the increase in annual household income within the region due to the increased agricultural production.

Assuming current land use, the impact of the Trinity River Project in Reaches 1 and 3 was greatest. Total additional annual regional household income due to increased agriculture income was estimated at $2,171,796.

Assuming profit maximizing land use with the project, the impact of the Trinity River Project in Reaches 1, 2 and 3 was quite large. The increase in regional annual household income resulting from increased agricultural income attributable to the project, assuming profit maximizing

Table 14

Present Values of Annual Net Benefits Discounted at 3¼% & 9% Interest Rates, Evaluation Reaches 1 through 6, Trinity River.

| Evaluation Reach | Capitalized Net Benefits From Project, Current Land Use | | Capitalized Net Benefits From Project, All Land in Most Profitable Enterprise | |
|---|---|---|---|---|
| | 3¼% | 9% | 3¼% | 9% |
| | - - - - - - - - - - - - - - - dollars - - - - - - - - - - - - - - | | | |
| Reach 1 | 13,080,169 | 4,723,394 | 14,958,478 | 5,401,709 |
| Reach 2 | 864,192 | 312,069 | 31,184,797 | 11,261,177 |
| Reach 3 | 8,018,911 | 2,895,718 | 82,174,708 | 29,674,200 |
| Reach 4 | 511,048 | 184,545 | 7,462,072 | 2,694,637 |
| Reach 5 | 390,649 | 141,068 | 6,433,138 | 2,323,078 |
| Reach 6 | 514,208 | 185,686 | 1,267,303 | 457,637 |
| Total | 23,379,177 | 8,442,480 | 143,480,596 | 51,812,438 |
| Less Capitalized Net Revenue Lost due to Inundation of Tennessee Colony Reservoir | 2,567,103 | 927,009 | 2,567,103 | 927,009 |
| Adjusted Net Benefits | 20,812,074 | 7,515,471 | 140,913,493 | 50,885,429 |

Table 15

Total Change in Regional Annual Household Income Due to Decreased Flood Damages, with Current Land Use and with All Land in Most Profitable Alternative Enterprise, Trinity River.[a]

| Evaluation Reach | Additional Regional Household Income with Current Land Use | Additonal Regional Household Income with All Land in Most Profitable Alternative Enterprise |
|---|---|---|
| | --------------------dollars-------------------- | |
| Reach 1 | 1,201,261.65 | 1,371,439.87 |
| Reach 2 | 106,019.73 | 2,859,100.14 |
| Reach 3 | 764,640.50 | 6,938,421.44 |
| Reach 4 | 37,957.02 | 489,642.49 |
| Reach 5 | 27,797.29 | 422,126.46 |
| Reach 6 | 34,120.47 | 83,157.28 |
| TOTAL | 2,171,796.66 | 12,163,887.68 |

[a]Regional economic impact of the project was estimated by applying multipliers from a state input-output study. A discussion of developing the multipliers is presented in the methodology section of this report.

land use, was estimated at $12,163,887.68. As before, these estimates represent a lower and upper bound of annual economic impact.

The capitalized values of additional regional household income are given in Table 16. Assuming current land use, the present values of additional regional household income were $66,824,513 at 3¼% and $24,131,075 at 9%. The capitalized values, assuming all land converted to the profit maximizing alternative enterprise, were $374,273,469 at 3¼% and $135,154,308 at 9%.

The total state impact of increased agricultural production was not included. But due to the location of large metropolitan areas at either end of the study area, the regional effects should serve as a close approximation of the total state effects. The annual increase in state household income would be expected to be slightly larger than the increase within the region.

## Producer Survey

A survey of 32 farmers and ranchers within the study area was conducted to determine the frequency of flooding, depth of flood waters, current land use, changes in land use that might occur if the project was completed, and opinions of producers regarding the project. Survey results for flood frequency and depth of flood waters were used to calculate flood damages.

A comparison of survey data and 1972 land use data obtained from the U. S. Department of Agriculture, Soil Conservation Service, Temple, indicated some land use changes have occurred. For example, several producers reported a change from cropland to pasture due to crop losses associated

Table 16

Present Values of Additional Regional Household Income at $3\frac{1}{4}$% and 9% Interest Rates, Evaluation Reaches 1 through 6, Trinity River.

| Evaluation Reach | Capitalized Additional Regional Household Income with Current Land Use | | Capitalized Additional Regional Household Income with All Land in Most Profitable Alternative Enterprise | |
|---|---|---|---|---|
| | $3\frac{1}{4}$% | 9% | $3\frac{1}{4}$% | 9% |
| | - - - - - - - - | - - - - - - - - | dollars - - - - - - - - | - - - - - - - - |
| Reach 1 | 36,961,897 | 13,347,352 | 42,198,150 | 15,238,221 |
| Reach 2 | 3,262,146 | 1,177,997 | 87,972,312 | 31,767,779 |
| Reach 3 | 23,527,400 | 8,496,006 | 213,489,891 | 77,093,572 |
| Reach 4 | 1,167,908 | 421,745 | 15,065,923 | 5,440,472 |
| Reach 5 | 855,301 | 308,859 | 12,988,507 | 4,690,294 |
| Reach 6 | 1,049,861 | 379,116 | 2,558,686 | 923,970 |
| Total | 66,824,513 | 24,131,075 | 374,273,469 | 135,154,308 |

with frequent flooding. Thirty-eight percent of the producers interviewed indicated that they would make changes in existing land use if the project was constructed. Sixty-two percent of the producers indicated they would not change the present use of their land. Many of the producers that indicated they would not change current land use were already in crop production but said they would increase the intensity of existing cropping patterns. Other producers that would not change existing land use were ranchers engaged strictly in livestock production.

Ninety-four percent of the producers interviewed indicated that they were in favor of the Trinity River Project. Several producers felt the project would improve the economy of the entire region. Some of the producers interviewed thought the multi-purpose channel would reduce the cost of inputs used in agricultural production due to lower transportation costs. Only six percent of the producers interviewed were opposed to the project. Those opposed to the project felt that it was economically infeasible or they opposed the tax increase. One producer that opposed the project already had flood protection via a levee and would lose some of his land if the project was constructed.

## Study Assumptions

It is important to point out limitations of any study of this type and particularly one done under the severe time constraint imposed. Therefore, the results of this study should be considered with the following assumptions or limitations.

The establishment of current land use within the 100-year flood plain was essential to estimate agricultural benefits attributable to the Trinity

River Project. The results of the study were based on the assumption that land use has not changed since 1972. However, interviews with producers indicate that some land use changes have been made since 1972 estimates were established. Furthermore, no crop rotations were considered in the study and not all land converted to crop production may be suitable for cropping due to slope, soils, or other factors.

Several assumptions were made in developing cost and return data for the study. Production of all crops was assumed to be under typical management while livestock production was considered to be under high level management. The enterprise budgets and assumed net returns may be limited by other factors present in the study. For example, prices paid and received used in the establishment of enterprise budgets are average prices for the study area over the 1970-1974 period. Additionally, net revenue could be increased with some land use changes under current conditions. Therefore, not all of the increase in net revenue can be attributable to the project. A possible limitation was present in estimating crop yields. In the study no allowance was made for fluctuations in the water table that might occur with the project and affect productivity.

Net returns attributable to the project may be underestimated due to benefits that were not considered in the study. For example the multipurpose channel should lower transportation costs for agricultural inputs such as fertilizer. A reduction in transportation costs would lower input costs and lead to further increases in net revenue.

Further limitations may be present in the methodology used to estimate flood damages. Estimates of flood frequency were obtained from the producer survey and the small sample size (32) may not be a truly representative sample. For example, frequency of flooding and depth of floodwaters as reported in the survey may reflect some dispersion from the actual occurrence of floods. In calculating flood damages, the duration of the period in which land was inundated by floodwater was not taken into account. If floodwaters remain for excessive time periods additional losses may be experienced. Present flood damages may be further underestimated since losses to productive timberland and pecan acreage were not considered.

In the evaluation of benefits attributable to the project only the "protected area" was considered. Additional benefits from a reduction in flood damages within the 100-year flood plain could be expected after project completion. It should be noted at this point that the study only considered floods with a 100-year frequency or less. Future floods above the with project 100-year flood plain were not considered in the study. Corps of Engineers personnel have reported that in many cases where a certain degree of protection is provided such as up to a 100-year flood, future floods which exceed this protection, such as a 200-year flood, cause significantly more damage than without the project at all (McFarland, 1976). Of course, the frequency of such a massive flood is rare; i.e., a 0.5% chance in a given year.